Treatment of resting muscle tension through transdermal sound waves of specific wavelengths

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PROJECT: Treatment of resting muscle tension through transdermal sound waves of specific wavelengths

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Impact:

- Melocura is a pain-free and non-invasive form of sound treatment without apparent side-effects
- A significant effect of a single Melocura treatment for 40 mins, was found on muscle function – improved coordination
- The AMG muscle function data support the EEG findings of an independent study From Korea with Easy Brain Centre, Gangnam, Seoul, South Korea.
- Melocura effects could be of use potentially for a number of reported conditions e.g. Stress, chronic pain, tensions, injuries, recovery, Cerebral Palsy, Fibromyalgia, Parkinson´s Disease.
- Melocura appears to have its principle effect through central rather than peripheral regulation of muscle function

Abstract:

Introduction: Sound therapy is of increasing popularity for treating conditions such as post-traumatic stress disorder (PTSD), autism, fibromyalgia, Cerebral Palsy (Wigram, 1997) and Parkinson´s Disease (Vincente et al., 1997), tinnitus and pain. It has been proven to be efficient in blood-pressure reduction, general relaxation and pain management (Boyd-Brewer & McCaffrey, 2004; Chesky, 1992; Wigram, 1997), however, to our knowledge, this is the first study to test the influence of a certain sound frequency on muscle status and motoric coordination, measured by multi-frequency bioimpedance and acoustic myography.

Materials and methods: 26 human subjects completed a full study protocol, i.e. two therapeutic sessions. During each session the subjects were measured using an mf-BIA and an AMG diagnostic device before and after listening to either a special frequency sound therapy (Melocura, Denmark, test 1) or normal relaxing music (NRM, test 2). The data were analyzed statistically using GraphPad InStat 3 for Mac (Version 3.0b, 2003; Graph- Pad Inc., La Jolla, CA).

Results: mf-BIA parameters indicated no statistically significant differences between the two tests in terms of improvement of muscular condition and muscle relaxation of studied subjects.
On the other hand, AMG data showed statistically significant differences in terms of improvement of muscle coordination and efficiency in favour of Melocura compared with Normal Relaxing Music.

Conclusion: Sound therapy of a certain frequency (Melocura) has a positive effect on muscle coordination and efficiency, measured by AMG and expressed in terms of the E-score. In contrast, Normal Relaxing Music had no proven effect on these same parameters.

PREFACE: This publication is the result of an innovation project entitled Treatment of resting muscle tension through transdermal sound waves of specific wavelengths.

The project is financed by Danish Sound Network through a grant from the Danish Agency for Institutions and Educational Grants and co-financed by the participating partners: MeloCura Institute of Sound therapy, CURO Diagnostics, and Aalborg University. The project is completed in the period 24.08.18 - 12.11.18 and managed by Aalborg University, and Project Manager Stefania Serafin.

Synopsis:

Resting muscle tension in human subjects is common (anxiety-, injury- related), and over time it can result in such debilitating conditions as for example chronic neck pain. Cochrane Collaboration has provided systematic reviews of some of currently applied interventions, such as exercise, massage, patient education, electrotherapy, mechanical traction, but sadly, the overall conclusion is that the evidence of these therapeutic interventions is uncertain and provides rather short-term solutions for pain management. The objective of this project has therefore been to develop muscle-specific sounds for treatment of resting tension.

Background Theory:

Since the late 1970s, when it became clear that ion channels are directly activated by mechanical force, the study of sensory transduction and especially those working on somatosensation has been of interest. With the very recent identification of the underlying proteins responsible for these channels, the focus has now shifted to understanding their functional roles and their regulation. Besides TRP channels, another group, which have been named Piezo (Piezo 1 & 2) proteins have been identified as being an essential component of mechanically activated channels – in fact they seem to be associated with the tense or chronic pain state.

Our preliminary findings with a neck muscle (m.Sternocleidomastoid) and a shoulder muscle (m.Trapezius) were interpreted as indicating a beneficial effect of transdermal application of sounds with a specific wavelength, capable of resetting known ion-channels and sensors in both muscle and connective (fascia) tissue, and inducing muscle relaxation.

However, the latest data set from a bigger subject cohort (n=26) would tend to argue against this mode of action, at least at a peripheral level. The lack of any significant change in the mfBIA data for the two muscles measured, in particular no observed change in the centre frequency (fc) that changes with the degree of resting tension in a muscle and its fascia, argues against a direct effect of sound waves of specific frequencies (Melocura) on muscles. Instead, the observed and significant improvement in the AMG E-score, representing the level of efficiency and coordination with which a muscle is used for a given task, suggests a more central effect of the Melocura sounds. This response most likely involves the motor cortex, cerebellum and the sympathetic nervous system.

This project has chosen to examine the effects of a single 40 min test with Melocura on a shoulder muscle (m.Trapezius), often affected by whip-lash injuries, computer work and poor posture, as well as the lower back muscle (m.Longissimus dorsi) often associated with strain, pain and reduced quality of life.

Materials & Methods:

Subjects:

A total of 46 subjects were recruited for this project, covering age range 19-59 (mean=39,9), both male and female subjects (ratio 10:16), weight range 55-90kg (mean=72,54kg), height range 164-189cm (mean=172,77cm), and average BMI=24,5, which is within the normal range. Of these, a total of 26 people completed all the measurements. Criteria for subjects' recruitment for the study have been one of the following or a combination of these: stress, lower back pain, neck and/or shoulder pain. All participants gave written, informed consent before participating in the study.

mfBIA:

Multi-frequency bioimpedance (mfBIA) measurements were taken from the *m.Trapezius* (shoulder) and the *m.Longissimus dorsi* (lower back).
The mfBIA measurements were undertaken using an ImpediMed Inc tetra-polar bioimpedance spectroscopy unit (Impedimed, Pinkenba, Qld, Australia) with matching ImpediMed electrodes according to the firm's recommendations. These measurements were made prior to and following a period of 40 minutes of listening to music via a pair of bone-phones (AfterShokz, Trekz Titanium). The average time spent by the subjects for each measurement was in the order of 60 minutes.
mfBIA measurements were made in a sitting position, ensuring that the subject was kept free of all metal and human contact. In each case, the four electrodes were placed onto the identified muscle sites, two at the insertion and two at the origin. For all electrode placements, the outer two electrodes provided the electrical field (Alternating Current), and the inner pair was used as sensing electrodes (Voltage). Measurements were carried out over a frequency range of 4-1000 kHz, applying 256 different frequencies which were plotted in real-time as a Cole-Cole plot. These values as well as the Cole-Cole plot could be seen for each subject as they were made, ensuring accurate data collection.
Subsequent data analysis was performed using the ImpediMed software provided, and then stored in an Excel file prior to statistical analysis.

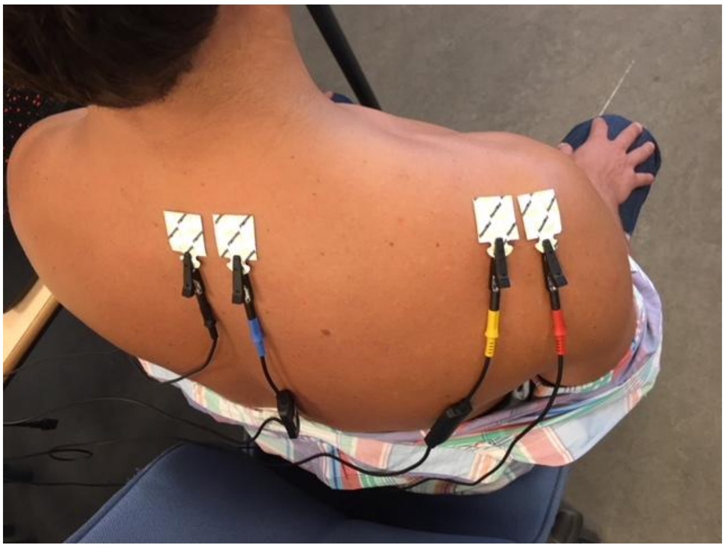

Figure 1. The picture illustrates a typical placement of electrodes for mf-BIA measurements on the right trapezius muscle of a test subject.

Acoustic Myography:

Acoustic myography (AMG) is a biomechanical method in that it evaluates tissues that generate pressure waves, e.g. contracting muscle. A CURO unit sampling at 4 kHz, attached to a 50mm piezoelectric crystal CURO sensor coated with acoustic gel was used. The CURO sensors were placed centrally on *m.Trapezius* (shoulder) and on *m.Longissimus dorsi* (lower back) for each subject. Connecting cables were run from the sensors and connected to the CURO unit that was placed alongside the subject on a flat shelf adjacent to the flat bed. The wires from the sensors were secured with a flexible adhesive bandage.

The parameters determined with this device are efficiency (E-score) as well as both spatial and temporal summation expressed by the S- and T-scores, respectively. The E-score corresponds to the time periods of active/inactive function relative to the duration of the activity period of the muscle (how long the muscle fibers are "on"). The S-score in terms of muscle reflects the recruitment of motor units and equates to signal amplitude (how many motor units are active). The T-score reflects the motor unit firing rate or signal frequency (how fast the motor units are firing).

Subsequent data analysis was performed using the CURO Diagnostics software provided, and then stored in an Excel file prior to statistical analysis.

Experimental Procedure:

Measurements took place at Aalborg University Copenhagen, Denmark, in an anechoic chamber. Recruitment of the subjects was via social media and e-mails. All subjects were asked to complete two therapeutic blind test sessions, each one lasting approx. 60 minutes together with the measurements: during the first session they were listening to Melocura, a specially designed sound therapy of certain frequency – 432 Hz (Melocura, Denmark) and during the second session a normal relaxing piano music was played. Subjects sat on the edge of the flat bed, placed inside the anechoic chamber, and were initially measured using the mfBIA unit as explained earlier, after which an AMG recording was made for both muscles – here the subjects were asked to extend their arms to approx. 90 degrees from their torso and to press the palms of their hands together 3

times, thereafter they were asked to bend forward 3 times as far as they could comfortably manage. Subjects were measured two times at each session – before and after listening to sound therapy or normal relaxing music (NRM). The purpose was to observe, if there were any differences in muscle response to the NRM or Melocura sounds.
The pulse was recorded for each subject Pre and Post both sound tests using a ChoiceMMed Pulse Oximeter (Bristol PA 19007, USA).

Data Handling:
The bioimpedance data were analyzed for the Centre Frequency (fc) and the Extracellular Resistance (Re), both of which were determined from the Cole-Cole plot. The intracellular resistance (Ri) was calculated from the formula: Ri = (Re x R∞/Re-R∞). Membrane Capacitance (M_c) was also calculated from the formula: fc = 1/(2π x Mc x (Re + Ri). A detailed analysis was finally performed at 50 kHz with measurement of Resistance (R) and Reactance (Xc), and a calculation of the Impedance (Z), where Z = Square Root ($R^2 + Xc^2$). Finally, so as to be able to compare between individuals of different body mass, the Phase Angle (PA) was calculated: PA = arctan (Xc/R) with units in degrees. The mfBIA parameters were interpreted in terms of muscle mass (Z, R), energy storage capacity/fibre size (Xc), hydration status (R, Re), tissue density/resting tension (fc), membrane activity/integrity (Mc) and metabolic activity (Ri).
The AMG signal was analyzed in terms of its individual components Efficiency (E-score) and fibre recruitment, Temporal (T-score) and Spatial (S-score) summation, which are all mean values made for periods of physical activity, as outlined earlier.

Statistics:
All statistics were performed using GraphPad InStat 3 for Mac (Version 3.0b, 2003; Graph- Pad Inc., La Jolla, CA). Data were initially tested for normal distribution and equal variance, and then subsequently analyzed using an unpaired t-test. Differences between means with a P value > 0.05 were considered non-significant. Values are presented as the mean ± the standard error of the mean.

Results:

mfBIA:
The data obtained from the mfBIA measurements for both the neck and back muscles can be seen in Table 1. It was found that subjects measured pre and post the two music tests, showed similar mfBIA parameters, which did not prove to be statistically significant from each other.

AMG:
The data obtained from the Acoustic Myography unit for both the neck and back muscles can be seen in Table 2. It was found that Melocura alone had a significant effect on both the E-score as well as the overall combined ESTi score. The overall ESTi score change was a 10.4% and 11.1% improvement, respectively compared with Pre- test values.

Pulse:
The Pulse measurements for the subjects in the Melocura test were; Pre 73.77 $\pm$ 20.92 bpm and Post 67.15 $\pm$ 16.45 bpm. For the normal relaxing music (NMR) test the values were; Pre 74.65 $\pm$ 20.57 bpm and Post 65.50 $\pm$ 21.75 bpm. For both tests the resting values were very similar and the Post values fell by 8% and 12%, respectively compared with Pre values. There was no significant difference between the two tests, nor any effect of treatment, despite a clear trend towards and fall in the pulse of the 26 subjects with both tests.

Discussion:

Specific Findings:

mfBIA: The mfBIA data obtained from the 26 subjects that completed this study, showed no difference Pre *versus* Post for either of the two sound tests. These findings are in contrast to the preliminary data (n=8) in which it was shown that there was a significant effect of Melocura on the muscle bioimpedance parameters (fc: muscle tension etc.). However, one can only assume that this preliminary data was subject to what is often referred to as a type I error, that is to say the rejection of a null hypothesis, also known as a "false positive" finding, as the result of too small a sample size. It is felt that the data set collected from the much larger sample size (n=26) is more precise, and represents a more accurate measurement of the effects of the music trials.

AMG: The AMG data obtained for the 26 subjects that completed this study showed a significant improvement in the efficiency/coordination of the neck and back muscle contractions that they performed Post Melocura as compared with Pre. These improvements in muscle function were significant for both muscles, not only showing a significant increase in the E-score, but also a significant overall effect of muscle function, as represented by the similarly improved integrated score (ESTi).

General Findings:

At the core of this project was the thought that certain sound frequencies could be used to activate Piezo channels through membrane oscillations thereby triggering tissue relaxation. Since the late 1970´s these Piezo channels have been known to be directly activated by mechanical force. Furthermore, with the very recent identification of the underlying proteins responsible for these channels, focus in the scientific community has shifted to understanding their functional roles and their regulation. Indeed our preliminary findings led us to think that muscle relaxation could be achieved through the transdermal application of sounds with a specific wavelength, capable of resetting these ion-channels and sensors in both muscle and connective (fascia) tissue.

However, the latest data set from a bigger subject cohort would tend to argue against this mode of action, at least at a peripheral level. The lack of any significant change in the mfBIA data for the two muscles measured, in particular no observed change in the centre frequency (fc) that changes with the degree of resting tension in a muscle and its fascia, argues against a direct effect of sound waves of specific frequencies on muscles. Instead, the observed and significant improvement in the AMG E-score, representing the level of efficiency and coordination with which a muscle is used for a given task, suggests a more central effect of the Melocura sounds. This response, which is not only very similar for both the muscles tested, but also of a relatively immediate duration, occurring within a period of only 40 minutes, and after just one treatment, most likely involves the motor cortex, cerebellum and the sympathetic nervous system.

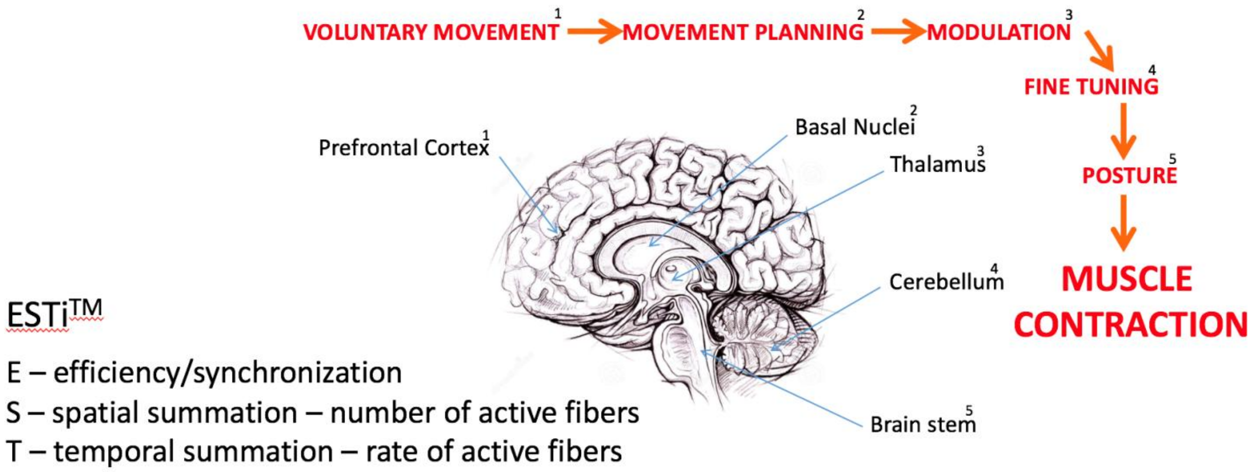

Figure2. A schematic showing the regions of the brain involved in muscle contraction, alongside the use of these parameters by the acoustic myography technique to evaluate muscle function and performance.

In an independent trial involving Melocura sounds, it has been shown that a 60 min trial induced a significant effect on the EEG of subjects in a region of the brain known as C3 & C4 (Easy Brain Centre, Gangnam, Seoul, South Korea). It is this particular region of the brain that is associated with processing touch and sensation, but more importantly keeping a track on the location of individuals body parts, a process often referred to as proprioception (De Boeck, 2010). More recent studies have shown that the C3 & C4 region also plays a role in motor imagery, which is an important mental process in cognitive neuroscience and cognitive psychology that has received considerable attention in recent years (Hu et al 2014). This is a particularly important region with function playing a key role in the training of individuals with gait performance issues and those recovering from ambulant strokes (Kumar et al 2016). Motor imagery is known to activate motor pathways, albeit without actual muscle contractions, it is thus central in terms of simulated actions and EEG activity tends to be proportional with the amount of imagined effort (Kumar et al 2016), as well as actual physical activity (Bailey et al 2008).

The findings of the Easy Brain Centre in Seoul, South Korea, are in agreement with the current findings where an improvement in muscle function was measured after a 40 min Melocura sound trial. Since it is now known that Melocura sounds induce an upregulation of the alpha2 signals in the C3 & C4 regions of the brain, it can be deduced that these sounds not only stimulate motor imagery with an anticipated improved movement and gait response, but perhaps of greater importance proprioception too. Proprioception changes have been shown to be grounded in kinematic alterations in response to a training protocol (Jensen et al 2018). However, it was Dr Janda who was the first to propose proprioception as part of the rehabilitation process, with implications for locomotor pathology, using sensorimotor training to emphasize correct postural control and gradually restore normal motor programs in patients (Page 2006). It would now seem that through stimulation of the C3 & C4 regions of the brain, by means of Melocura sounds, both motor imagery and proprioception can be enhanced with clear benefits for motor function in human subjects.

In the study published by Wigram (1997) it was shown that the use of vibroacoustic therapy in Cerebral Palsy patients was efficient at reducing muscle activity and elevated muscle tone. A pulsed 44 Hz tone was used with pre-recorded relaxing music for the 30-minute experimental session and the same music without the pulsed tone for the control session. Ten subjects received 6 randomly chosen sessions each. Average range of motion for spinal mobility and limb flexion and extension were measured pre-sessions and post-sessions. The study results indicated that subjects with increased muscle tone consistently demonstrated a reduction in muscle tension and improved range of motion with the vibroacoustic-pulsed music sessions over the music-alone group (Wigram, 1997).

Generally, studies suggest benefits from sound and vibroacoustic therapy, however, there appear to be many variables in the type of equipment employed, frequencies and/or music used, as well as the methodology adopted in these different studies. Continued research is necessary to adequately determine parameters of optimal sound therapy use for the healthcare field.

Limitations:
This project was initiated in order to recruit as many participants as possible within the timeframe available, so as to increase the statistical value of our preliminary trial. Whilst we had hoped for some 30 subjects, only 26 people from 46 recruited managed to complete both tests. The reason for this was the test was done over 2 different sessions. The test was a blind test comparison between normal relaxing music and effects of MeloCura. The participants from the study listened to the MeloCura sound therapy in the first test week and in the second week they listened to normal music. The participants suffered from server chronic conditions such as stress and pain and many did not return for the second test using normal relaxing music as it was difficult for them to make the travel to the university and also the fact that they had to enter an anchoric chamber and the fact that they had to remove clothes in order for the sensors to be placed did not make the environment optimal for participants suffering from stress. Thus the comparison remains on the 26 participants in this study. It would be optimal to test on patients in a clinic on a daily basis.

This proved sufficient to reach statistical significance, but this data set may be too small to adequately represent a large group of people, for example those suffering from conditions such as stress, muscular tension/pain and lower back pain.

During some tests, technical problems with the bioimpedance equipment were experienced and therefore, a few of the mf-BIA measurements have been excluded from further statistical analyses (n=15 out of 208 measurements taken – 7%).
Some subjects found it difficult to follow the precise instructions given as to how they should perform the exercises (AMG measurements), and this therefore raises the issue of strict uniformity in this study, although it does embrace individual variation, which always creeps into pre-clinical and clinical trials.

Conclusion:

It is concluded that Melocura sound therapy, with a single 40 min test, has proven efficacy in the improvement of muscle efficiency and coordination, as measured and tested by use of Acoustic Myography. It would be fascinating to measure the effects of a prolonged period of treatment, as well as other important muscles e.g. m. Sternocleidomastoid, often involved in whip-lash injuries. Furthermore, the results of this study although promising, should ideally be investigated with a larger group of subjects, also in combination with other measurements e.g. EEG or blood markers assessment in order to consolidate and extend the appropriate application of this novel technique.

Tables:

Table 1: mfBIA data collected for the 26 participants and the two muscles measured in this test. Values for the Melocura sound test Pre and Post as well as the Normal Relaxing Music (NRM) sound test Pre and Post are presented as Means ± SD. Statistical analysis of these data revealed no significant effects of sound treatment.

	Melocura			*NRM*		
	Pre	*Post*	*Stats*	*Pre*	*Post*	*Stats*
Trapezius (Neck Muscle)						
Impedance (Z) Ω	*75.74 ± 20.90*	*70.92 ± 16.33*	*NS*	*77.10 ± 21.81*	*70.06 ± 23.97*	*NS*
Resistance (R) Ω	*75.19 ± 21.08*	*69.79 ± 17.14*	*NS*	*76.48 ± 21.99*	*69.53 ± 24.05*	*NS*
Reactance (Xc) Ω	*8.68 ± 1.99*	*9.75 ± 6.39*	*NS*	*9.23 ± 2.03*	*8.07 ± 2.53*	*NS*
Phase Angle °	*6.80 ± 2.94*	*6.58 ± 3.22*	*NS*	*6.80 ± 3.15*	*6.52 ± 3.09*	*NS*
fc (kHz)	*55.85 ± 11.23*	*56.68 ± 11.91*	*NS*	*57.20 ± 11.42*	*56.81 ± 16.72*	*NS*
Re Ω	*89.89 ± 22.58*	*85.62 ± 17.89*	*NS*	*91.12 ± 23.26*	*82.23 ± 26.56*	*NS*
Mc nF	*12.52 ± 4.45*	*13.74 ± 7.60*	*NS*	*12.03 ± 4.98*	*11.25 ± 4.59*	*NS*
Ri Ω	*192.71 ± 112.78*	*172.46 ± 105.54*	*NS*	*192.27 ± 118.56*	*180.72 ± 116.68*	*NS*
L.dorsi (Back Muscle)						
Impedance (Z) Ω	*83.81 ± 26.52*	*80.51 ± 26.79*	*NS*	*70.40 ± 27.04*	*69.99 ± 27.71*	*NS*
Resistance (R) Ω	*83.26 ± 26.78*	*79.97 ± 26.98*	*NS*	*67.22 ± 29.87*	*69.57 ± 27.73*	*NS*
Reactance (Xc) Ω	*8.74 ± 2.21*	*8.72 ± 2.26*	*NS*	*7.19 ± 3.54*	*7.09 ± 2.89*	*NS*
Phase Angle °	*6.22 ± 3.51*	*6.67 ± 3.36*	*NS*	*5.76 ± 3.77*	*5.56 ± 3.24*	*NS*
fc (kHz)	*46.74 ± 14.52*	*50.28 ± 14.67*	*NS*	*35.08 ± 16.07*	*40.00 ± 14.91*	*NS*
Re Ω	*101.43 ± 27.43*	*97.28 ± 28.16*	*NS*	*82.52 ± 34.48*	*83.87 ± 31.26*	*NS*
Mc nF	*14.74 ± 8.32*	*14.61 ± 8.45*	*NS*	*14.25 ± 7.74*	*13.39 ± 7.23*	*NS*
Ri Ω	*211.69 ± 125.01*	*195.30 ± 110.38*	*NS*	*184.27 ± 132.81*	*197.54 ± 129.39*	*NS*

Table 2: AMG data collected for the 26 participants and the two muscles measured in this test. Values for the Melocura sound test Pre and Post as well as the Normal Relaxing Music (NRM) sound test Pre and Post are presented as Means ± SD. Statistical analysis of these data revealed significant effects of Melocura sound treatment for both the neck and back muscles alike.

	E-score	*Stats*		*S-score*	*Stats*		*T-score*	*Stats*		*ESTi-score*	*Stats*
Trapezius (Neck Muscle)											
Melocura											
Pre	*5.54 ±2.65*	*P<0.05*		*9.50 ±0.30*	*NS*		*5.20 ±2.46*	*NS*		*6.75 ±1.30*	*P<0.05*
Post	*6.67 ±2.28*			*9.40 ±0.53*			*6.29 ±3.32*			*7.45 ±1.41*	*10.4% ↑*
NRM											
Pre	*5.70 ±1.66*	*NS*		*8.93 ±1.73*	*NS*		*6.67 ±2.21*	*NS*		*7.10 ±0.30*	*NS*
Post	*5.97 ±1.91*			*8.83 ±2.07*			*5.78 ±2.51*			*6.86 ±0.31*	
L.dorsi (Back Muscle)											
Melocura											
Pre	*4.61 ±2.48*	*P<0.05*		*8.20 ±1.39*	*NS*		*6.49 ±2.73*	*NS*		*6.43 ±0.71*	*P<0.01*
Post	*5.86 ±2.32*			*8.83 ±0.90*			*6.75 ±2.40*			*7.15 ±0.85*	*11.1% ↑*
NRM											
Pre	*3.93 ±2.63*	*NS*		*7.72 ±2.25*	*NS*		*6.92 ±2.08*	*NS*		*6.19 ±0.28*	*NS*
Post	*4.54 ±2.71*			*8.29 ±0.95*			*6.48 ±2.58*			*6.44 ±0.98*	

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